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HOSPITAL TECHNICAL MEMORANDUM

ANTI-STATIC PRECAUTIONS: FLOORING IN ANAESTHETISING AREAS

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Anti-static Precautions: Flooring in Anaesthetising Areas

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I. Scope

1. This memorandum gives guidance on the need for anti-static floors in anaesthetising areas, and the specifications of flooring which will satisfactorily meet hospital requirements in this respect. It draws attention to recent advances in the production of various flooring materials with satisfactory conducting and wearing properties, and to improved electrical testing methods. New recommendations are given on resistance limits. Recommendations on other anti-static precautions in anaesthetising areas are given in Hospital Technical Memorandum No. 1.

II. General

2. The extent of the risk of electrostatic sparking in areas where flammable anaesthetics are used was discussed in the Report of the Working Party on Anaesthetic Explosions published in 1956. The Report recommended that anti-static precautions should be taken in all areas where anaesthetic apparatus employing a closed or partially closed breathing circuit is used with flammable anaesthetics.

3. An essential part of anti-static precautionary measures is the provision of a floor which ensures the safe discharge of static electricity from persons, trolleys and other objects which have effective anti-static contact with the floor surface. The electrical resistance of the floor should not be too low, however; otherwise the risk of electric shock associated with equipment connected with mains electricity may be seriously increased.

III. Earthing

4. Previously an earthing connection has been recommended for anti-static floors to assist in the rapid dissipation of electrostatic charges. Experience has shown that where floors have suitable electrical conducting properties, safe equalisation of electrostatic charges between objects in electrical contact with the floor can be achieved without a direct earthing connection. The capacitance of the floor will ensure that any electrostatically charged objects which are brought in from another area are rapidly discharged. The omission of an earthing connection will assist in keeping the electrical resistance to earth sufficiently high to reduce the electrical shock risk.

IV. Places where anti-static floors are required

5. Anti-static floors should be provided in rooms in which anaesthetic apparatus having a closed or partially closed breathing circuit is likely to be used with flammable anaesthetic, and in any corridor or lobby which has to be traversed in moving a patient from one anaesthetising area to another whilst still connected to the anaesthetic apparatus.

6. Anti-static floors will normally be required in operating theatres, anaesthetising rooms and in maternity delivery rooms. They should be provided in x-ray rooms only if flammable anaesthetics and closed circuit anaesthetic apparatus are likely to be used there. (The use of flammable anaesthetics and provision of anti-static floors in x-ray rooms is discussed in the Report of the Working Party on Anaesthetic Explosions.)

7. The anti-static floor should extend either to the walls or to at least 6 ft. around any position where anaesthetic apparatus may be used. Where the sterilising area adjoins and is open to the theatre or delivery room the anti-static floor should extend to the sterilising area.

8. Although special anti-static flooring is not considered necessary in rooms and corridors immediately adjoining the anaesthetising areas, the use of highly electrostatic floor finishes should be avoided in such places. Examples of electrostatic flooring to be avoided are ordinary rubber, P.V.C., cork and asphalt. Some sealing treatments (e.g. those having a urea formaldehyde base) may render wooden or other floors highly electrostatic.

V. Recommended limits of electrical resistance

9. When tested in the way described in this memorandum, the recommended limits of electrical resistance are:

With floor surface dry: average value not exceeding 2 megohms (2×10^6 ohms) between two separate electrodes, and no individual reading exceeding 5 megohms (5×10^6 ohms).

With floor surface wet (under the electrode only): average value not less than 50,000 (5×10^4 ohms) between one floor surface electrode and a known earth, with no individual reading less than 20,000 (2×10^4 ohms).

10. All new floors in anaesthetising areas should be constructed to comply with these limits.

VI. Factors affecting the resistance of anti-static floors

Existing floors

11. In assessing the suitability of existing floors for anti-static purposes, it is necessary to take into account the extent to which flammable anaesthetics are used and the condition and suitability of the floor in other respects.

12. The recommended limits of electrical resistance include a safety margin against the possibility of some variation of resistance occurring under service conditions. Resistivities somewhat higher than the recommended upper limit may be satisfactory provided the normal anti-static precautions, such as the elimination of the use of highly electrostatic materials and the provision of anti-static castors, footwear, etc., have been taken.

13. For example, in places where flammable anaesthetics are regularly used, and the condition of the floor is satisfactory in other respects, average values of resistance of less than 20 megohms (2×10^7 ohms), with no individual test value exceeding 50 megohms (5×10^7 ohms), can be considered satisfactory. Where the resistance of the floor exceeds these values, steps should be taken, as the opportunity and resources permit, of providing a new floor with satisfactory anti-static properties.

14. High resistance floors can be rendered temporarily anti-static by damping the surface; this treatment is recommended when flammable anaesthetics are in use. The use of a wetting agent, such as a detergent, in the water will increase the duration and effectiveness of the treatment.

New floors

15. The moisture content of terrazzo and similar floor finishes has a considerable effect on its electrical resistance. Such floors normally have low electrical resistance initially and it may take some months for the floor to dry out sufficiently to enable reliable test results to be obtained.

16. With anti-static vinyl and similar anti-static floor coverings the electrical properties of the materials on which they are laid can have a significant effect on the final resistivity of the floor. Because of this, electrical resistance measurements may vary considerably although a similar floor covering material is used. The use of an electrically conducting adhesive will increase this effect while an insulating adhesive will, of course, assist in isolating the floor covering from the sub-floor. The initial resistance of anti-static rubber and similar floors may be influenced by flexing and strain imposed before and during laying, but the resistance of these floors normally becomes stabilised within ten days.

VII. Electrical tests

Recommended test instrument

17. The test instrument recommended is an insulation testing ohm-meter, having an approximate open circuit voltage of 500 volts D.C. and capable of measuring resistance values of between 10,000 ohms (10^4 ohms) and 50 megohms (5×10^7 ohms).

Test electrodes

18. Each electrode should have a flat surface area of approximately four square inches and should weigh about two pounds. The floor contact surface should consist of a tin or tin faced lead foil 0.0005 in.–0.001 in. thick, backed by a layer of soft rubber and a weight of approximately the same dimensions. The test lead should be connected direct to the foil, e.g. by a small spring clip.

Method of test

19. Dry test: Two electrodes should be placed approximately 2 ft. apart and the resistance measured between them. The floor surface should be wiped clean with a dry cloth before the electrodes are applied. Dry tests may not be reliable if made within two hours of the floor being wetted, e.g. for cleaning.

Wet test: The floor surface in contact with the electrode should be wetted, but the wetted area should not greatly exceed the area of the electrode. A wetting agent, e.g. a detergent, should be used where necessary to ensure uniform wetting. One electrode should be placed on the floor and the resistance measured between the electrode and a known earthing point, e.g. water-tap or electric conduit.

Number of tests

20. Sufficient dry and wet tests should be made for the results to be representative of the resistivity of the whole floor surface being tested. As a general indication, one dry and one wet test should be made for each two square yards of floor area.

Results

21. The results of the dry and wet tests should be separately averaged and the average values and individual test values should be within the limits of electrical resistance specified above.

VIII. Types of flooring

22. The sub-floor construction will influence the choice of floor finish. Where the sub-floor is suitable for a rigid type of finish, terrazzo flooring is usually preferred for operating theatres, anaesthetic rooms and delivery rooms. The electrical resistance of terrazzo floors is rather difficult to control particularly with in-situ constructed floors, and wide variations can arise unless a satisfactory specification is used and rigidly adhered to. Good quality terrazzo has a hard, impervious finish, which has fairly stable electrical properties, but porosity associated with inferior terrazzo can cause wide fluctuations in resistivity. Hydraulically pressed, precast terrazzo tiles generally have more stable electrical properties than in-situ terrazzo floors.

23. Anti-static ceramic tiles offer an alternative type of rigid flooring. Experience in this country with this type of flooring is limited, but it is extensively used abroad, notably in the United States. A 4 in. × 4 in. tile having a matt blue/grey glaze finish is now available in this country. To obtain lateral continuity between tiles it is necessary to use an electrically conducting bedding and/or grouting material between tiles. The indications are that with a suitable laying specification consistent and lasting anti-static properties can be achieved with floors incorporating these tiles.

24. Where a resilient type of floor finish is required or where the depth available for the floor finish is restricted, anti-static vinyl type flooring is usually preferred. Some anti-static rubber and linoleum floors have been laid, but vinyl has the advantage of greater resistance to staining fluids and solvents and the joints can be welded after laying. Carbon black has been largely used as the conducting medium and the electrical resistance of floors incorporating carbon black has been generally satisfactory. Earlier types of anti-static vinyl floors were black but the material is now available in other colours with black patterning. With this type of heterogenous material, no point on a non-conducting area should be more than $\frac{1}{4}$ in. from a conducting surface.

25. Other conducting agents have also been used to impart anti-static properties to rubber and P.V.C. types of flooring. These have been found to be less satisfactory than carbon black and the reliability of anti-static agents other than carbon black has yet to be proved. To encourage development there is no objection to new types of anti-static flooring being laid in small trial areas, but satisfactory assurances as to their lasting properties should be obtained before they are used for larger areas.

Anti-static floors with embedded heating systems

26. The resistivity of terrazzo may increase seriously where a heating system is incorporated in the sub-floor. Similar variations may also occur where an embedded heating system is incorporated in the ceiling directly beneath an anti-static floor, unless adequate steps are taken to restrict the temperature rise of the floor. This arises from the fact that an increase in the operating temperature of the floor reduces the residual moisture content and thereby raises the resistivity. The fluctuations which can occur under these conditions will probably result in the electrical resistance of terrazzo type floors exceeding the limits recommended for anti-static purposes, and the use of terrazzo with embedded floor heating systems is not recommended in places where anti-static precautions are necessary.

27. The resistivity of anti-static vinyl and similar floor coverings which incorporate carbon black as the conducting agent may also be affected by heat, but the variations will probably be small and not enough to cause the resistance of these types of flooring to fall outside the recommended limits. When ordering anti-static floor coverings for use with embedded heating systems it is advisable to state what is the maximum operating temperature of the floor.

Service pipes buried in anti-static floors

28. Whenever practicable metal service pipes should not be buried in the screed or bedding of anti-static floors. Where this is unavoidable steps should be taken to prevent contact between the pipes and the wire mesh, e.g. by the use of building paper, polythene film or similar separating materials.

IX. Recommended floors

(*a*) **Terrazzo: in-situ**

29. The materials used and the method of construction should be generally in accordance with British Standard Code of Practice C.P. 204. Attention is specially drawn to the clause dealing with the prevention of cracking.

Special materials required

Wire netting:

Heavily galvanised steel wire netting, not thinner than 22 s.w.g. and mesh not exceeding 1 in., complying with B.S.1485.

Binding wire:

22 s.w.g. galvanised steel binding and jointing wire, complying with B.S.184.

Carbon black:

Carbon black produced from the thermal decomposition of acetylene gas or other types of carbon black which will impart similar electrical conducting properties to the floor should be used. To obtain satisfactory diffu-

sion throughout the mixture, the carbon black should be in powder form, dry and free from lumps.

Method of laying

(i) The sub-floor and separating layer (if any) should be prepared in the usual way and be free from dust or grease, etc.

(ii) The netting should be laid over the entire surface area prepared for the screed. There should be a slight overlap at the sides of the longitudinal runs and these should be bound together at distances not exceeding three feet with 22 s.w.g. galvanised binding wire.

Note: Bare copper binding wires should not be used because of the possibility of electrolytic action between copper and the zinc galvanising.

Where the screed thickness is less than $1\frac{1}{2}$ in.* or where a separation layer is used it is recommended that the mesh is secured to the sub-floor at intervals of approximately two feet to reduce the possibility of the terrazzo rising away from the sub-floor. (Special nails can be bought for this purpose.)

(iii) The screed between the terrazzo topping and the sub-floor should have a thickness of $1\frac{1}{2}$ in.–$2\frac{1}{2}$ in.* and should consist of 1 part cement, 4 parts of aggregate, consisting of sharp washed sand and $\frac{1}{4}$ in.-$\frac{3}{8}$ in. shingle or crushed aggregate, properly graded according to thickness. The carbon black should be added to the cement in the ratio 2 lb. of black to every 100 lb. of cement. The cement and black should be thoroughly mixed dry. To obtain uniform electrical properties throughout the floor special care must be given to this mixing and it is recommended that it is done in a mechanically driven mill or mixer. The amount of mixing water should be the minimum consistent with proper workability. Where the screed is less than $1\frac{1}{2}$ in. thick special attention should be given to ensuring a good bond to the sub-floor and to securing the wire mesh as described above.

(iv) The terrazzo topping should not exceed $\frac{5}{8}$ in. in thickness and should be laid as soon as practicable (and certainly within two days) of the laying of the screed. The terrazzo should be composed of 2 parts marble aggregate grades 0 and 1 (approximately $\frac{1}{8}$ in.–$\frac{3}{16}$ in.) to 1 part cement. After mixing and spreading, grade 2 (approximately $\frac{3}{8}$ in.) marble aggregate should be closely sprinkled over the surface and thoroughly tamped and rolled in to provide a compact surface with the maximum amount of marble aggregate. The aggregate should be free from dust and impurities, and the water to cement ratio should be kept as low as is practicable to prevent excess shrinking on drying and decrease the risk of cracking.

(v) Dividing strips should be plastic or ebonite and penetrate the full depth of the terrazzo and screed. They should be bedded into grooves provided in the screed by anti-static mortar similar to the screed.

(vi) Fine surface grinding treatment is necessary to obtain the required smooth, imperforate finish as obtained for example with an 80 grit polishing stone.

(vii) The floor should be kept in a damp condition for several days after laying, and subsequently should be covered as necessary to prevent a too rapid drying out, e.g. during the summer months or where the floor will be subjected to artifical heat.

(*b*) **Terrazzo precast tiles**

30. The construction should be generally in accordance with British Standard Code of Practice 202 and with the following:

Size of tiles

The preferred size is 12 in. × 12 in. or 30 cm. × 30 cm., 1 in. nominal thickness. Other sizes may be used provided the thickness does not exceed $1\frac{1}{2}$ in.

Composition of tiles

The terrazzo facing of the tile should be not less than $\frac{1}{4}$ in. and not more than $\frac{3}{8}$ in. thick, and should consist of properly graded marble aggregate to produce a mix not richer than 2 parts aggregate to 1 part cement by volume.

The tile backing should consist of 3 parts of suitable aggregate to 1 part cement. The amount of mixing water should be the least needed for proper workability.

Manufacturing pressure on the tile should be at least 500 lb. per square inch.

Method of laying

The sub-floor or separation layer (where provided) should be prepared and covered with wire mesh as described for in-situ terrazzo.

The bedding mortar should consist of cement and sharp, washed sand not richer than 1 part cement, 3 parts sand, and should not exceed

*Screeds having a minimum thickness of less than $1\frac{1}{2}$ in. are not recommended and should not be used with a separation layer between the screed and the sub-floor. Under no circumstances should the thickness be less than $1\frac{1}{4}$ in.

½ in. thickness. It is unnecessary to incorporate carbon black in the bedding mortar where the floor will be maintained within normal temperature limits, i.e. where there is no buried heating. The joints should be pointed with similar cement to match the tiles.

Finish

Where a smooth, lip-free surface is required the floor should be ground, after a suitable curing period, using a fine abrasive, e.g. an 80 grit stone, as recommended for in-situ terrazzo.

(*c*) **Anti-static ceramic tiles**

31. The tiles should have a non-slip finish and a degree of electrical conductivity to enable the recommended resistance limits to be obtained and to be maintained after laying.

Method of laying

(i) The sub-floor should be level and smooth to allow the use of a uniform bedding ½ in.-¾ in. thick. An electrically insulating membrane, e.g. polythene film laid on the sub-floor before the bedding will assist in achieving consistent resistivities irrespective of the sub-floor construction. Joints in the membrane should overlap at least 3 in.

(ii) The sand-cement-carbon black mix described in 29 (iii) is suitable for the bedding mortar. The water content should be kept to the minimum that is necessary to obtain proper workability. Excessive water will cause cracks on drying which can affect the conductivity.

(iii) The tiles should be bedded so that the bedding mortar rises half way up the edge of the tiles on all sides.

(iv) A waterproof grouting should be used, e.g. 1 part cement, 1 part fine sand with a suitable waterproof additive.

(v) After the grout has set the floor should be kept damp and free from pedestrian traffic for 4–5 days.

(*d*) **Anti-static P.V.C., rubber, and linoleum floor coverings**

32. Floor coverings of these materials are usually supplied in widths of 3 ft. or 6 ft., or in tile form. There are obvious advantages in using the greatest width to reduce the number of joints. The surface of the materials should preferably have uniform conductivity but where for purposes of embodying a pattern small non-conducting areas are included, they should be arranged so that no point on a non-conducting area is more than ¼ in. from a conducting surface.

33. The work involved in laying should be generally in accordance with British Standard Code of Practice C.P.203 and with the following:

Preparation of sub-floor

The sub-floor should be even, clean and dry, and if in direct contact with the ground should incorporate an effective waterproof membrane. Uneven floors should be screeded to produce a flat, even surface to receive the floor covering. It is usually preferable for screeding to be carried out by the flooring contractor to ensure that the screed is compatible with the adhesive to be used to secure the floor covering.

Where the sub-floor has significant electrical conductivity, e.g. it is of concrete or similar construction, this may considerably lower the electrical resistance between the anti-static floor covering and earth, particularly where an electrically conducting adhesive is used. In such instances an electrically insulating membrane should be applied to the sub-floor, before the anti-static floor covering is laid.

Electrical bonding

Satisfactory uniform electrical conductivity throughout the floor is important and where flooring is in strip or tile form it will be necessary to provide some form of electrical bonding between strips or tiles. This can be achieved by the use of metallic strips or alternatively an electrically conducting adhesive can be used. A highly conducting coating on the underside of the floor covering material will assist in obtaining uniform conductivity throughout the floor, and with this facility, where floors are laid in continuous strips, a single transverse bonding strip will usually be sufficient. With tiles, a bonding strip will be necessary under each row of tiles and another interconnecting strip at right angles. Bonding strips should be insulated from any earthed metalwork encountered (see para. 4).

Bonding strips should be unjointed and consist of brass or copper, e.g. 1 in. wide, 0.003–0.006 in. thick. (*Note.* Material having a tinned or other protective finish should be used when there is a risk of corrosion.) Where an insulating adhesive is used care should be taken that the adhesive does not impair contact between the bonding strip and the underside of the flooring material. The permanence of electrically conducting type adhesives should be verified before they are used. To ensure close joints there should be no adhesive on the edges of the tiles which should be dropped carefully (not slid) into position.

X. Marking of anti-static floors

34. It is frequently useful to know the history of anti-static floors and it is recommended that they are marked, e.g. with a brass plate inserted in a suitable position and finishing flush with the surface, and inscribed with the following information:

ANTI-STATIC FLOOR LAID BY . . . (name of firm), type . . . , date . . . .

XI. Maintenance

35. It is important that the maintenance of anti-static floors should not impair their anti-static properties. Wax and other polishes and seals which leave a film on the surface of the floor are liable to do so.

36. The best method of maintenance from this point of view should be ascertained by electrical testing and should then be carefully followed.

Terrazzo and ceramic tile floors

37. These floors may be freely washed, using, where necessary, a mild (neutral) cleansing powder. Soap and soap powders should be avoided, because unless the floors are thoroughly rinsed afterwards a soapy film remains which tends both to impair the anti-static properties and to make the floors slippery.

38. Sealing compounds are available for treating the surface of terrazzo floors and these have the effect of reducing the marking of floors by rubber tyres, etc.; they also facilitate cleaning. Tests have shown that some sealing compounds do not significantly affect the anti-static properties of the floor, but this is not true of them all. Before treating large areas, therefore, it is recommended that a small trial area be treated and the electrical resistance of the area measured (after a suitable drying-out period) and compared with the test results obtained on an untreated area, to ascertain that the treatment does not detract significantly from the anti-static properties of the floor.

Anti-static rubber and linoleum floors

39. These forms of flooring may be washed, using the minimum amount of water and a mild (neutral) cleansing powder where necessary. Soaps and detergents are not recommended. If too much water is used it may penetrate into joints and destroy the adhesion.

40. Spirits, oils, grease and wax have a seriously adverse effect on the anti-static properties, and cleansers, disinfectants and polishes incorporating these substances should not be used.

Anti-static vinyl floors

41. Vinyl floors may be washed with the minimum amount of water and a detergent (liquid or powder) may be used. Floors having soundly welded seams may be washed more freely.

Periodic testing

42. The electrical resistance of anti-static floors should be measured periodically (at about three-monthly intervals) using the test method described, the floors being divided into sections and the results entered in a log book so that a continuing history of the various sections is recorded.

References

BRITISH STANDARDS INSTITUTION

1. B.S.184: Galvanized steel binding and jointing wires.
2. B.S.1485: Galvanized wire netting.
3. B.S.2050: Electrical resistance of conductive and anti-static products made from flexible polymeric material.
4. B.S.3398: Anti-static rubber flooring.

CODES OF PRACTICE

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